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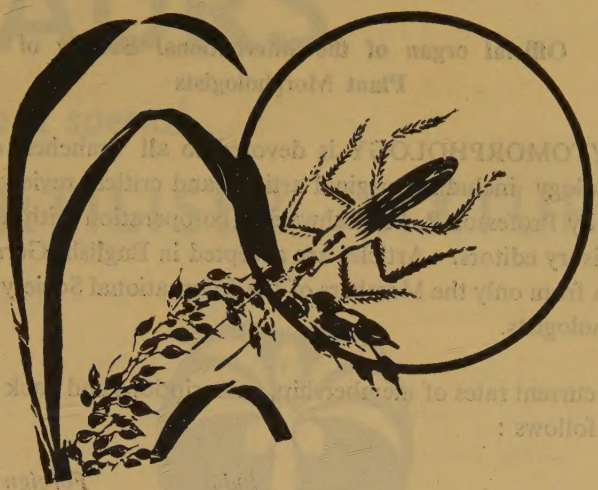

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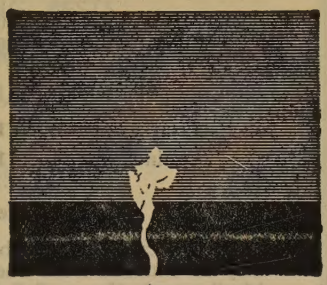

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EDITORIAL

Cultivation of Local Yams

ALTHOUGH accurate statistics regarding the extents under the different local yams (roots and tubers) are not available, it is generally believed that there has been no appreciable increase in the cultivated acreage in recent years. On the other hand it is even likely that there has been a gradual decline in the extents under some species of yams. The ready availability of the imported potato and the lack of general interest in yams as a substitute for rice is perhaps the chief reason for the failure of the local yams to attain the popularity they richly deserve. As was clearly demonstrated during the war years the local yams can safely replace the potato, besides providing a full meal hardly inferior to rice.

Unlike the fastidious potato, most of the local yams are hardy and require very little care and attention after planting. They are also heavy yielders and yields ranging from 5 to 10 tons per acre are not uncommon with good cultivation and manuring. Another commendable feature of the local yams is that several of them can be planted even outside the regular planting seasons so as to provide an almost continuous supply of fresh yams. Most of the local yams are highly adaptable to varying conditions of soil and climate and as such they can be cultivated with success in almost every part of the Island except at the very high elevations. Other than bandicoots and rats, there are no serious pests or diseases that prove troublesome in the cultivation of the local yams. The local yams should, therefore, figure prominently in any food production programme in the Island.

Manioc and sweet potato are two root crops that require special mention because of the facility of cultivation. Manioc in particular is highly drought resistant and can be cultivated with very little effort even in the Dry Zone. Although there is some prejudice against the consumption of manioc due to the fear of prussic acid poisoning, the different varieties tested and released by the Department of Agriculture are perfectly safe unless the yams have been damaged and exposed after harvest. Even those who prefer to avoid manioc should find sweet potato a very acceptable yam that cannot produce any ill-effects. In fact, sweet potato is gaining wide popularity in several western countries and in the Phillipines as being more nutritious than the real potatoes.

The Alocasias and Colocasias which comprise several varieties that take from three to nine months to come into harvest are another important group of root crops that can provide a continuous supply of fresh yams. As the plants resemble the garden Caladiuem, they can be grown in any home garden without disfiguring it.

Dioscoreas and Innala are highly seasonal and can be cultivated only once a year, and perhaps for this reason there has been no great expansion of their acreage inspite of their popularity. Except for those who traditionally cultivate these crops, few others have shown interest in their cultivation. However, in view of the urgent need to produce more food in the country, an expansion of the Dioscorea acreage will be most desirable. The cultivation of Dioscoreas is particularly commended as their keeping-quality is far superior to that of other local yams.

BIOLOGY OF HELOPELTIS CEYLONENSIS DE SILVA (HETEROPTERA-MIRIDAE), A MAJOR PEST OF CACAO IN CEYLON *

MERVYN D. DE SILVA,

(Agricultural Research Officer, Gurutalawa, Ceylon)

INTRODUCTION

NUMEROUS members of the extremely large and widely distributed family *Miridae* (formerly Capsidae), are highly destructive pests of cultivated plants. They have been recorded to be responsible for serious damage to a wide range of economic crops. *Lygus viridanus* Motch. produces a symptom referred to as "corroded leaf" on tea in Ceylon (Calnaido, 1959). *Lygus praetensis L.* produces "dimpling" on apples in the United States (Hammer, 1939). In the Gold Coast and Nigeria, *Sahlbergella singularis* Hagl. and *Distantiella theobroma* Dist. cause widespread damage to the cacao crop (Voeleker and West, 1940). In Ceylon, the mirids belonging to the Genus *Helopeltis* cause significant economic losses to crops such as tea and cacao (De Silva, 1957).

Although, the majority of mirids feed on plant juices, some of them are decidedly predatory and are therefore beneficial. The genus *Cyrtorhinus,* which is widespread and cosmopolitan, feed on the eggs of homopterous insects embedded in plant tissue. *Cyrtorhinus mundulus* (Bredd.) found in Australia, Java, the Philippine Islands and Fiji, is particularly associated with the eggs of the Sugar Cane leafhopper, *Perkinsiella saccharicida* Kirk. and is considered to be the most efficient controlling agent of the pest (Sweetman, 1958). Several species of mirids are also predacious on mites. The best known example is the case of the black kneed bug, *Blepharidopterus angulatus* Fall., an important predator of the fruit tree red spider mite, *Metatetranychus ulmi* in England (Gilliat 1935).

* Based on work carried out by the author, while attached to the Division of Entomology, Peradeniya, during the years 1956-57.

HISTORICAL BACKGROUND AND DISTRIBUTION OF THE GENUS HELOPELTIS

THE history of the genus *Helopeltis* dates back to the year 1858 when the French entomologist, Signoret (Ann. Soc. Ent. Fr. (3) 6, P. 502) erected it in order to receive the species *Helopeltis antonii* recorded from Ceylon and Burma. The genus *Helopeltis* now includes numerous species recorded from many countries in the Oriental and Ethiopian regions. These insects are able to thrive on a range of host plants, all of which are not necessarily of economic importance. The two most important crops attacked in Ceylon are cacao and tea (Green, 1901).

The earliest recorded species of *Helopeltis* in Ceylon, *Helopeltis antonii,* was first observed as a pest attacking cacao in the year 1880 or 1881 in the Matale district and was well known for the severe damage it caused to the young shoots and growing stems of the cacao plant (Green, 1901). However, extensive collections made from the major cacao growing areas, including the Matale district, have failed to provide any specimens referable to *Helopeltis antonii* (De Silva, 1957).

The new species, *H. ceylonensis* differs from *H. antonii* in respect of its darker colouration, the relatively longer and thicker basal antennal segment, the more robust and less erect scutellar spine, more prominent antennophores and in having a foveole on the postocular.

As rational methods of control must be based upon a knowledge of the life history and habits of the insect involved, the purpose of this paper is mainly to present such information.

METHODS AND MATERIALS

THE studies on the life history of *H. ceylonensis* were carried out during the months September through November 1956. Material was collected at the Cacao Research Station, Kundasale.

A large petri-dish with a soaked filter paper placed in the lower half and with the upper half darkened by pasting a piece of carbon paper was a suitable arrangement for breeding *Helopeltis* in the laboratory. Pieces of cacao introduced for feeding were replaced every three days. All the laboratory observations were made at room temperature of approximately 23.9° C.

DESCRIPTION AND LIFE HISTORY

EGG (plate 1, fig. 1)

THE eggs are layed either in groups or singly and are inserted deep into the tissue of the cacao pod. They are elongate with the main axis bent to a varying degree depending on the condition of the tissue. The operculum and club shaped chorionic process of the egg are exposed. The location of the egg on the pod can be recognised by a minute scar produced in the process of oviposition and by the presence of the two protruding chorionic processes. The following are some of the measurements of the egg and duration of incubation period.

Total length (excluding processes) ..... 1.25 mm.—1.5 mm.
Length of chorionic processes ..... 0.5 mm.—0.75 mm.
Average duration of incubation of eggs ..... 11-15 days approximately.

1st INSTAR (plate 1, fig. 2)

Antenna: Segment 1 ochreous, rest ferrugino—testaceous; setae piceous.

Basal segment of antenna much thicker than remaining segments; segment of antennae and legs with moderately long errect setae; head as broad as thorax; head and thorax with erect setae; abdomen with two parallel rows of sub-dorsal setae and few lateral setae posteriorly; rostrum extending almost to base of the abdomen.

Length ..... 2 mm.
Duration of instar ..... 3-4 days.

2nd INSTAR (plate 1, fig. 3)

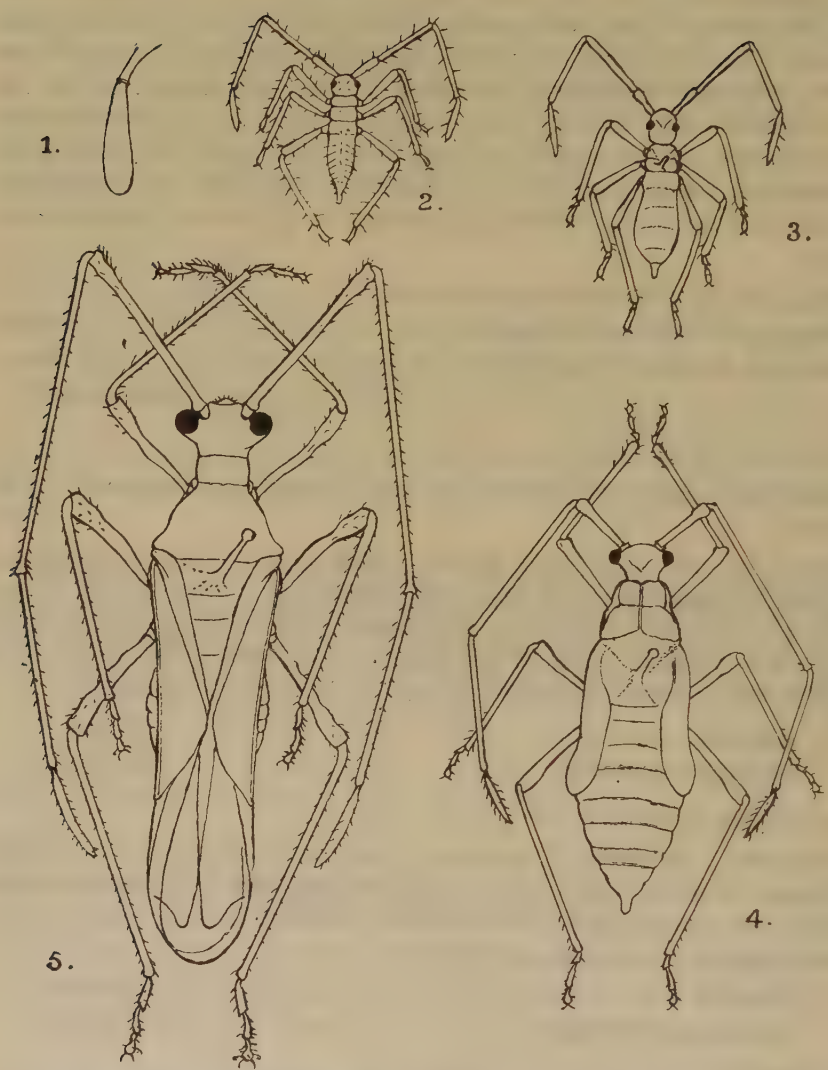
Antenna: Segment 1 brownish, rest dark brown, head, thorax abdomen and legs brownish; legs and segment 1 of antenna with bright red spots; eyes red. Thorax broaded than head; scutellar spine present, short and cylindrical.

Length ..... 2.5 mm.
Duration of instar ..... 2-3 days.

3rd INSTAR

Antenna: Segment 1 ochreous, rest ferrugineous; head, thorax, and abdomen ferrugineous; wing pads brown distinguishable; scutellar spine prominent.

Length ..... 3 mm.
Duration of instar ..... 2-3 days.



1. Egg 1½ mm. 2. 1st instar 2 mm. 3. 2nd instar nymph 2½ mm.
4. 5th instar nymph 5½ mm. 5. adult female 8½ mm.

4th INSTAR

Antenna : Segment 1 and 2 and legs pale yellow, rest of antenna ferrugineous ; head, thorax and wing pads dark brown ; abdomen pinkish ; eyes red. Wing pads prominent.

Length ..... 4 mm.
Duration of instar ..... 2-3 days.

5th INSTAR (plate 1, fig. 4)

Antenna : Segment 1 pale yellow, rest ferrugineous ; head, thorax and abdomen brown, wing pads deep brown with posterior extremities piceous ; legs pale yellow with drak brown patches. Basal segment of antenna relatively slender in relation to previous instars ; scutellar spine robust.

Length ..... 5.5 mm.
Duration of instar ..... 3-4 days.

SUMMARY OF NYMPHAL INSTARS
(at room temperature of approx. 23.9 C.)

Stage	*Minimum*	*Maximum*	*Mean*
Average period of incubation of eggs ..	11	15	13
1st instar	3	4	3.5
2nd instar	2	3	2.5
3rd instar	2	3	2.5
4th instar	2	3	2.5
5th instar	3	4	3.5
Total nymphal life	12	17	14.5
Period from egg to adult ..	23	32	27.5

Helopeltis ceylonensis is found in almost all the cacao growing areas of Ceylon with a record of heavy infestation in the Dumbara Valley (Fernando and Manikavasagar, 1956).

The nymphs and adults of *H. ceylonensis* are shade loving insects and are usually found on the shaded sides of the pods. They feed during all hours of the day, and produce approximately 10-50 feeding punctures per day, depending on the stage and size of the insect and on the condition of the pods fed on.

The entire life cycle of *Helopeltis* is spent on the cacao pods and trees. The adults and nymphs disperse quickly from the pods to the branches when disturbed. Eggs are deposited as a rule on the pods and less frequently on tender shoots and stems. Egg laying on stems usually occurs when cacao pods are scarce.

Copulation takes place during the day and the insects have been observed to remain *in coitu* for close on 45 minutes oviposition occurs at all times of the day.

DAMAGE

ONE of the most striking features in the feeding behaviour of *H. ceylonensis* is that this insect preferentially feeds on the pods and less frequently on the stems and growing shoots. This observation is not in agreement with that reported earlier for *Helopeltis antonii* (Green, 1901). In the case of the latter species, damage to the vegetative parts of the tree is the characteristic feature.

The insertion of the stylets into the plant tissue for feeding, by both adults and nymphs of *H. ceylonensis* produces quick visible reactions. A few minutes after the insertion of the stylets into the plant tissue, a circular area presenting a " water soaked " appearance develops around the point of insertion. The water soaked area which is deep translucent green initially becomes depressed and deep brown in colour in about 2 hours, finally turning black in about 24 hours.

Studies made on the feeding lesions produced by the mirids, *Sahlbergella singularis* and *Distantiella theobroma* in West Africa have shown that the primary water soaking effect surrounding the point of insertion of the stylets during feeding is due to the histolytic effect of the esterases in the saliva injected into the wound. No organic pathogens were found in the saliva of the species (Goodchild, 1952).

During the course of the laboratory studies, a record was kept of the diameter of the feeding punctures for each instar and the number of punctures produced on the pod, per 24 hour feeding (Table 1).

Table I. The diameters of the feeding lesions, and number of punctures produced per day by the 1st-5th instar nymphs and adult of H. ceylonensis.

Instar	*Size of Punctures (diameter in mm.)*			*Number of Punctures per Day*		
	Mean	*Max.* Min	*Min.* Max	*Mean*	*Max.*	*Min.*
1st ..	1.1	0.8	1.5	15	20	10
2nd ..	1.5	1.0	2.0	25	35	15
3rd ..	2.0	1.5	2.5	25	30	20
4th ..	2.0	1.5	2.5	25	30	20
5th ..	2.7	2.5	3.0	35	45	25
Adult ..	3.2	2.5	4.0	40	50	30

The size of the lesions produced by the 1st instar ranged from 0.8 to 1.5 mm. The size of the punctures increased from an average of 1.1 mm. in the 1st instar, to an average of 3.2 mm. in the case of the adult. The number of punctures produced per day also varied, from 10 to 20 with an average of 15 in the case of the 1st instar, to 30-50 with an average of 40, in the case of the adult.

On the basis of these results an approximate estimate of the potential damage *H. ceylonensis* could effect during the different nymphal stadia or stages was calculated. On an average, *H. ceylonensis* is capable of producing 180-255 lesions during its entire nymphal life. It is therefore not surprising that a very small population is sufficient to cause conspicuous damage (Table II).

Table II. Number of lesions produced during the nymphal stadia of the 1st, 2nd, 3rd, 4th and 5th instar of *H. ceylonensis.*

Instar	*Number of Punctures produced per Stadium*		
	Mean	*Max.*	*Min.*
1st	52.5	60	45
2nd	37.5	45	30
3rd	37.5	45	30
4th	37.5	45	30
5th	52.5	60	45
Total nymphal life ..	217.5	255	180

NATURAL ENEMIES

ALTHOUGH the nymphs and to a certain extent the adults of *H. ceylonensis* are slow moving forms, no efficient parasite or predator was recorded. A hymenopteran nymphal parasite, *Euphorus helopeltidis* Ferr., with a hyperparasite *Stictopisthus javenis* Ferr. had been obtained from *Helopeltis antonii* in Java (Miller, 1941). Careful observations of field collected eggs and nymphs had shown no indication of any parasite. The reduviid, *Sycanus collaris* Fabr. was found to be predacious on the nymphs of *H. ceylonensis.* Observation on their predatory feeding behaviour have shown them to be of no importance from the point of view of being able to depress populations of *H. ceylonensis.*

ACKNOWLEDGEMENT

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THE CONCEPT OF MOISTURE REGIMES AND ITS APPLICATION IN IRRIGATION RESEARCH

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INTRODUCTION

Field crops showing moisture stress are not an unfamiliar sight, even in the 'Rainy' climate of Ceylon. Wikramanayake (1958) has shown that in Peradeniya a moisture deficient period (drought) of 10 days or less could be expected four years out of ten during the main vegetable growing season. Dry spells during critical periods of growth, always result in reduced yields. In the 'dry zone' the dry period from June to September seriously limits crop production during the Yala. These hazards could generally be avoided, if supplementary irrigation was available at the right time and in the right amounts. Till very recently, methods of arriving at irrigation requirements for crop plants, were largely empirical. Fortunately, these are now being replaced by more reliable techniques, which allow a greater degree of irrigation control and which offer definable and reproducible methods of evaluating the soil moisture relations of a crop.

Experimental evidence with a number of crops has shown that a soil maintained at or near field capacity is conducive to optimal plant growth. Under these conditions the soil holds the maximum amount of water it can hold against the forces of gravity. Once a soil begins to dry, it becomes necessary to assess the stage at which lack of moisture becomes limiting to plant growth. In recent years Penman (1953) has provided a fairly satisfactory and workable solution to the problem of assessment of the rate of moisture loss, basing his calculations on the assumption that simple meteorological data can be related to the water lost by a green cover. Thus the moisture deficit in a soil at any particular time can be worked out and irrigation applied.

CONCEPT OF MOISTURE REGIMES

HUDSON et al (1955) advanced an equally useful concept when they stated that in order to find the critical stage in the drying cycle, which would be limiting to plant growth, one approach was to grow the plants in a series of different, definable and reproducible moisture regimes in each of which the soil moisture is allowed to fluctuate only between two pre-determined conditions, one being field capacity and the other a measurable stage in the drying cycle. Moisture regimes are chosen based on pre-determined tensions beyond each of which the soil is never allowed to dry at any time, moisture tensions being particularly useful, because they are related to the forces that must be overcome by a plant when it takes up water. At these pre-determined tensions the soil is irrigated to bring it back to field capacity and the overall effect of the treatments is then assessed on the basis of their effect on growth and yield.

EXPERIMENTAL PROCEDURE

IN an attempt to estimate the soil moisture deficits that could be allowed to develop without serious loss of yields in grassland subjected to frequent defoliations, Appadurai (1961) in an experiment conducted at Wye in England, applied the concept of moisture regimes to a perennial rye grass/white clover pasture subjected to two intensities and two frequencies of cutting.

TREATMENTS

THE following treatments were included in the experiment:—

(A) *Cultural*:

Heights of cutting:

Close cut—cut each time to 1″ above ground level.

Lax cut—cut each time to 2½-3″ above ground level.

Stage of growth at cutting:

Grazing stage—cut each time when approximately 8″ high (leafy).

Silage stage—cut each time when approximately 14″ high (long, leafy to early flower).

(B) *Irrigation*:

Three soil moisture regimes were imposed as follows :—

(A) Wet—Maintained at or near field capacity by watering every time the soil moisture tension reached 10 cm. Hg.

(B) Medium—Restored to field capacity every time the soil moisture tension reached 50 cm. Hg.

(C) Dry—Restored to field capacity once in the middle of the growing season.

The A and B soil moisture regimes were definable and reproducible. Since a suitable dry regime could not be imposed within the scale of the tensiometer, an arbitrary C regime was included.

The twelve treatment combinations were replicated 3 times in a randomized block design and enclosed in a Dutch light structure erected over the experimental area, in order to prevent any rain falling on the soil surface, and in order to facilitate the maintenance of definable and reproducible moisture regimes. Each plot measured a sq. yard.

Requirements for the maintenance of specific moisture regimes.

The maintenance of a specific moisture regime requires :—

(1) A satisfactory method of assessing soil moisture tension so that the soil is not allowed to dry beyond the pre-determined condition.

(2) A method of calculating the moisture deficit in the soil at the pre-determined tensions.

(3) The application of the correct amount of water to re-wet the soil to field capacity.

(4) A suitable method of measuring the amount of water applied.

In order to satisfy the first condition "Key tensiometers" (Galenkamp's growers model) were installed in each of the plots of one replicate and buried at a depth of a foot. Moisture tensions were recorded daily and every time the tensiometers registered the pre-determined tensions, all plots in that regime were irrigated back to field capacity, with the calculated amounts of water.

The second requirement was satisfied by plotting the curve relating soil moisture tension to soil moisture percentage (wt./wt.) for the soil of the experimental area. Permanent wilting percentage was

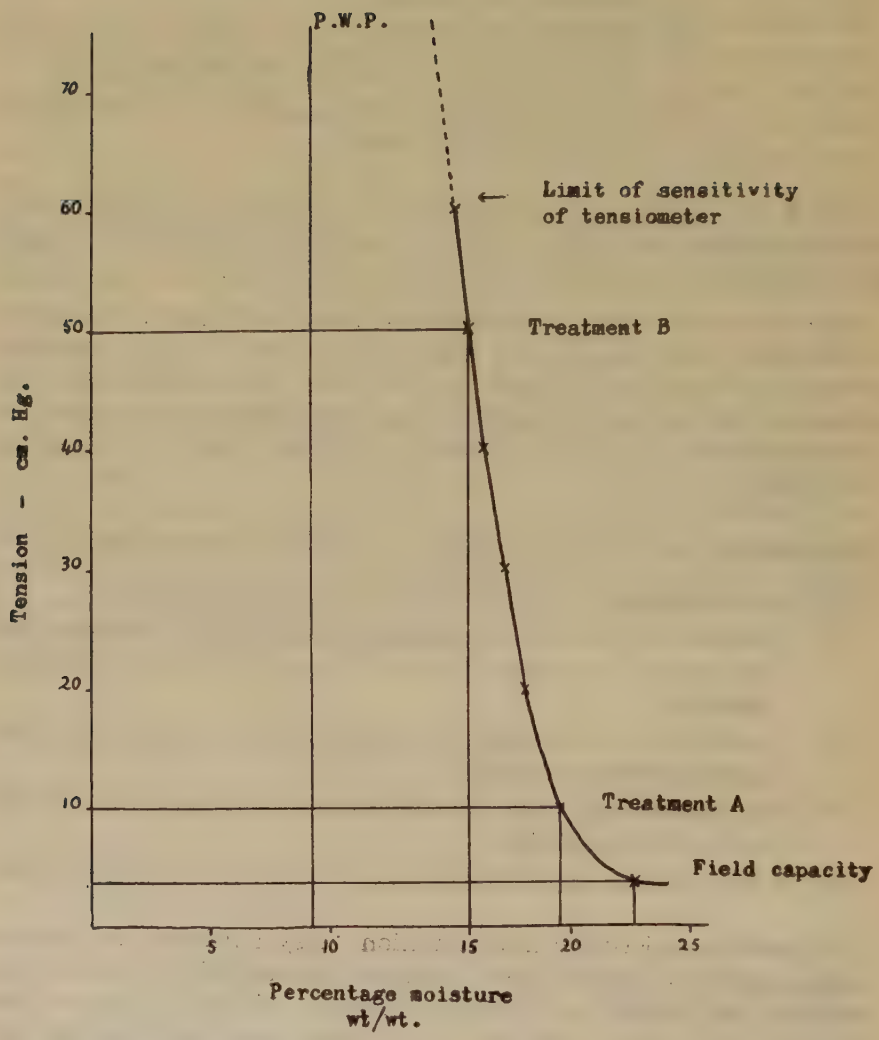

Fig. 1—Soil moisture curve.

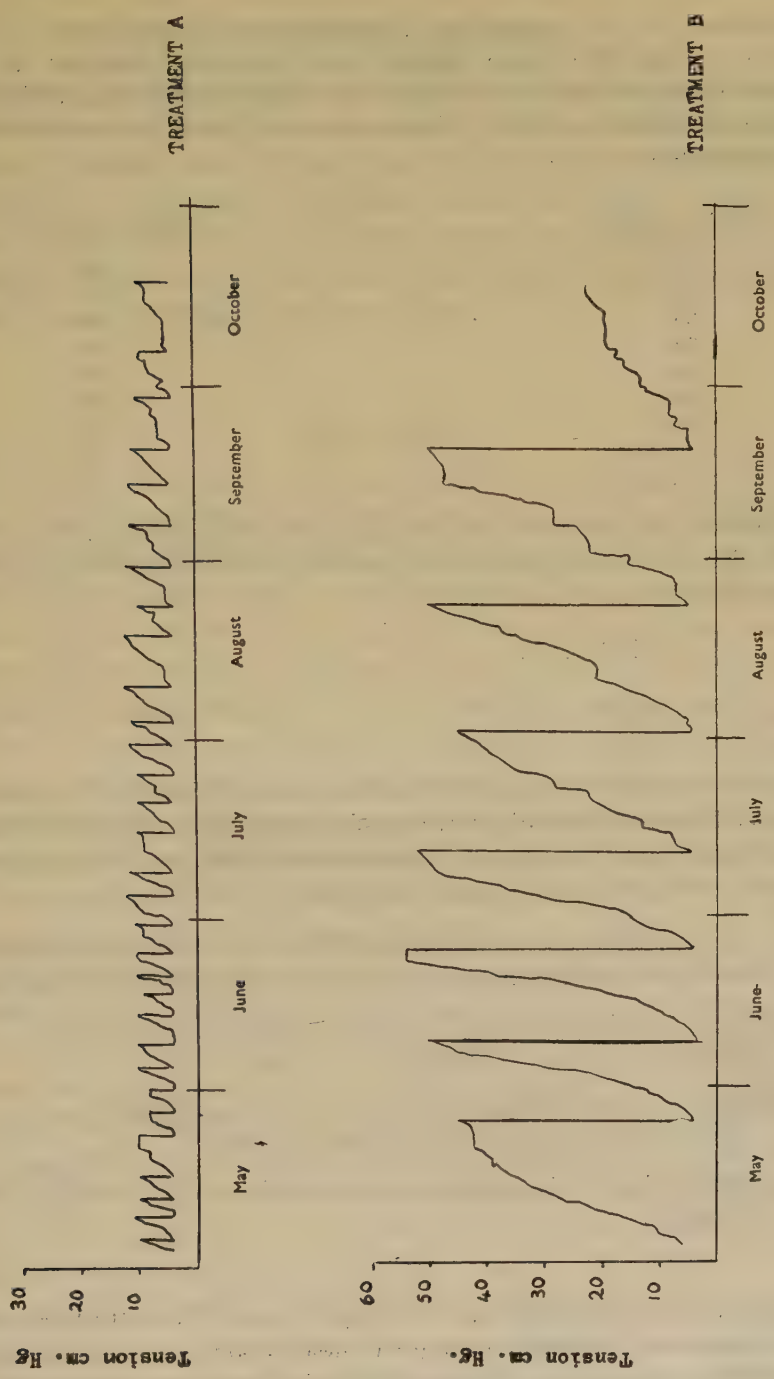

Fig. 2—Soil moisture tensions recorded daily at a depth of one foot under two different moisture regimes—1960.

determined by the method of Veihmeyer and Hendrickson (1949). Figure 1 shows the curve relating soil moisture tensions to soil moisture percentages for the soil of the experimental area, which was a deep, well drained chalky loam and was based on the following set of data :—

Tension cm. Hg.	*Moisture % (wt./wt.)*
4	22·8
10	19·7
20	18·4
30	17·4
40	16·6
50	15·8
60	15·4
P. W. P.	9·2

The third requirement was met by using the formula by North (1959) for converting percentage moisture deficit into inches, which is as follows :—

$$d = \frac{P \times As\ D}{100}$$

where d equals the amount of available water in inches, P equals the amount of water held at field capacity minus the amount of water held at permanent wilting on a percentage basis. As is the apparent density of the soil, and D equals the depth of soil in feet.

On this basis the calculated amounts of water required to bring 2 feet of this soil to field capacity at the pre-determined tensions were:

(*a*) When tensions reached 10 cm. Hg.—3.96 gallons/sq. yd. (Deficit in inches=0.4464 per foot of soil).

(b) When tensions reached 50 cm. Hg.—9.00 gallons/sq. yd. (Deficit in inches= 1.008 per food of soil).

(*c*) Deficits for the C regime were calculated by gravimetric determination.

The fourth requirement was met by the use of a calibrated water flow meter. All plots were brought to field capacity at the commencement of the experiment. Subsequent irrigations were determined by treatments.

EXPERIMENTAL RESULTS

MEAN total dry matter yields of mixed herbage, for two years of the experiment (1959-1960) are shown in Table 1, together with the relevant irrigation data. Figure 2 shows the soil moisture tensions recorded daily throughout the season under the A and B moisture regimes during 1960, the vertical lines representing the frequency of irrigation. Table 2 shows the analysis of variance of total dry matter yields of mixed herbage for the two years.

DISCUSSION

DURING both years there were clear responses to irrigation, but the water needs of the sward seemed to be related to the defoliation treatment imposed. The moisture regimes caused significant differences in dry matter yields, the highest dry matter yields of mixed herbage being obtained with a plentiful water supply. Dry matter yields of mixed herbage under the B and C moisture regimes were 91% and 70% respectively in 1959, and 76% and 54% respectively in 1960 of the yields under the A regime. The highly significant interaction between the type of cut (heights of cutting) and moisture regimes indicated that although close cutting resulted on average in significantly higher yields than lax cutting, yield differences between the two were modified by the moisture regimes imposed. It is clear that re-growth was progressively reduced by close cutting in the treatments in which the moisture level was allowed to fall much below field capacity. These results are in close agreement with the findings of Jantii and Kramer (1956). On the other hand as far as lax defoliation is concerned, the extra yield in terms of both fresh and dry weights obtained under the A regime were obtained at the cost of much more water applied per unit weight of mixed herbage than was the case under the B regime. At the same time treatment B, in which moisture deficits of 1″ were allowed to develop between each watering, was evidence of an economy in water use when a lax defoliation was imposed, but restricted the re-growth of swards that were closely defoliated. Low and Armitage (1959) after defoliating swards to 1—2 inches at the grazing stage found that a deficit of 2 inches was clearly limiting to growth.

CONCLUSIONS

THE techniques described above, which were applied to the study of irrigation requirements in grassland, can be profitably used to study the soil moisture relations of any crop, provided some method of preventing rain falling on the soil surface can be found. In experimental plots and in the green house this should be easy, and the results obtained can then be applied under field conditions. In any case the techniques described enable a greater degree of irrigation control and can be used to gain information not only on how much water to apply, but also when to apply this water in relation to the stage of growth of any crop. Finally, they enable one to determine the latest stage in the drying cycle at which water should be applied before lack of moisture becomes limiting to plant growth.

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TABLE 1.—Mean total dry matter yields of mixed herbage

1959

Moisture Treatment	Tension at which water applied cm.Hg.	Irrigation Data			Mean total yield 100 lb. d.m/acre				
		No. of times water applied	Total amount applied per plot (gallons)	Total amount applied in inches per acre	Grazing Stage		Silage Stage		Mean
					Lax	Close	Lax	Close	
A (wet) ..	10	39	156	34·6	83·3	118·1	84·4	118·7	101·1
B (medium)	50	9	81	18·0	85·2	91·4	85·1	108·0	92·4
C (dry) ..		1	36	8·0	69·7	79·6	71·2	64·3	71·2
				Mean	79·4	96·3	80·2	97·0	

S.E.= ± 3·41

1960

Moisture Treatment	Tension at which water applied cm.Hg.	Irrigation Data			Mean total yield 100 lb.d.m/acre				
		No. of times water applied	Total amount applied per plot (gallons)	Total amount applied in inches per acre	Grazing Stage		Silage Stage		Mean
					Lax	Close	Lax	Close	
A (wet) ..	10	30	120	26·6	100·0	120·6	109·6	136·7	116·7
B(medium)	50	7	63	14·0	81·9	83·7	85·2	102·4	88·3
C (dry) ..		1	15	3·3	58·1	62·0	68·7	64·5	63·3
				Mean	80·0	88·7	87·8	101·2	

S.E.= ±2·40

3——R 4960 (9/62)

TABLE 2.—Analysis of variance of Total dry matter yields of mixed herbage 1959, 1960

Source of Variation	d.f.	Mean Squares	
		1959	1960
Blocks	2	6769·19^{ns}	30917·53**
Treatments	11	85615·09***	162624·99***
Grazing vs. silage ..	1	406·69^{ns}	81130·03***
Lax vs. close ..	1	225783·36***	96824·70***
Moisture regimes ..	2	250849·36***	753014·69***
Stage vs. type ..	1	9·96^{ns}	4160·25^{ns}
Stage vs. moisture ..	2	15196·94^{ns}	2822·18^{ns}
Type vs. moisture ..	2	73247·01**	38332·99**
Type × state × moisture ..	2	18489·68^{ns}	9210·13^{ns}
Error	22	9256·31	4572·95
Total	35		

***Significant at the 0·1% level.
**Significant at the 1% level.

PRELIMINARY STUDIES ON THE ASSOCIATED GROWTH OF GRASS AND LEGUMES

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Although there is abundant evidence to show that legumes such as white clover, materially influence the yields of pasture herbage in the temperate zones (1, 2), corresponding evidence for pasture legumes in the tropics and sub-tropics is almost lacking.

These workers (1, 2) have shown that grassland with a fair proportion of legumes, yields much more than grass alone, and frequently as much or more than can be stimulated by the application of nitrogenous fertilizer.

In a mixed sward, the legume performs a three fold function.

1. It promotes increased production of herbage and of live-weight as a result of nitrogen made available by the legume.
2. It improves the quality of the feed, owing to its greater richness in constituents such as protein, calcium and fats.
3. It also increases the production potential of the land. Apart from doubts about the ability of pasture legumes to fix atmospheric nitrogen under tropical and sub-tropical conditions, considerable efforts have been made to find suitable legumes in many tropical regions.

Generally, there are 3 main sources of nitrogen for the growth of grass in an ungrazed grass/legume association.

(i) added fertilizer nitrogen,

(ii) nitrogen fixed by legumes and their root and nodule decay,

(iii) mineralized soil organic nitrogen.

Under conditions of grazing, however, the ultimate influence of either the legume or added nitrogen fertilizer is magnified by the returns of nitrogen to the sward in the dung and urine of the grazing animal, when several fertility cycles may occur in one season.

Of the several indigenous and exotic legume species, which were tested for their suitability as pasture legumes to be included in grazing mixtures, the following legumes have been outstanding.

(*a*) Pueraria phaseoloides,

(*b*) Centrosema pubescens,

(c) Alysicarpus vaginalis.

Pueraria phaseoloides

Pueraria phaseoloides, popularly known as " tropical kudzu " is a vigorous perennial which produces excellent bulk in the rains. It is persistent and drought resistant. The plants grow very slowly for the first few months, after seeding. It is widely used as a cover crop in rubber and coconut plantations in Ceylon. Tropical Kudzu is very sensitive to over grazing and repeated cutting to ground level and accordingly, needs careful management.

Centrosema pubescens

This is another aggressive, creeping perennial which is widely used as a cover crop in the plantation agriculture. It is slow in early establishment but grows rapidly after 2-3 months. It flowers profusely in December/January and produces a fairly heavy seed crop. It is persistent and drought resistant and can withstand grazing better than Pueraria.

Alysicarpus Vaginalis

This is an indigenous, prostrate perennial, which is commonly found in natural pastures in both Wet and Dry Zones of the Island. It is less leafy but persistent and drought resistant. There are a number of ecotypes of which the selected strain, when well established, grows to a height of 1½ ft. to 2 ft. It flowers profusely in December/January and April/May and produces a good crop of seeds. It is often subject to a virus disease, which is of a seasonal nature.

All these legumes are successful when grazed in a mixed sward. Establishment from seed is not a problem as in the case of grasses.

The performance of these legumes has been investigated in two field experiments, under conditions of both grazing and cutting.

PART I

Experimental

To ascertain the contribution of legumes in an ungrazed sward, and at the same time to gather information on ancillary issues of the interaction of legumes, Nitrogen and phosphate fertilizers, a trial was laid down at the Dry Zone Research Institute, Maha Illuppallama in Maha 1959. A 3 x 3 x 2 factorial design was employed with a plot size of 1/200 acre. The eighteen treatments comprising interactions of Branchiaria brizantha with and without legumes, at 2 levels of Nitrogen and 3 levels of phosphates, were each replicated three times. A single application of nitrogen (Ammonium sulphate), and phosphate (basic slag) was given in November 1960 at the rate of nil (N_0) and 80 lb. N/acre (N_1) and nil (P_0), 40 lb. (P_1) and 80 lb. P_2O_5(P_2) per acre, respectively.

The legumes, Alysicarpus vaginalis and Centrosema pubescens were sown in rows 2 feet apart at a seed rate of 6 lb./acre and the grass was planted in between the legume rows at a distance of 2 x 2 ft. The results reported here refer to the 1960/61 Maha and 1961 Yala season when three harvests were taken.

RESULTS AND DISCUSSION

1. Botanical Composition

(*a*) *Influence of Nitrogen on the botanical composition.* The effect of nitrogen on the percent legume content of the swards is shown in Table I.

TABLE 1.—Effect of nitrogen on percentage legumes in the grass/legume associations (on dry weight basis)

	N_0	N_1
1st Cut		
Brachiaria + Alysicarpus	53·3	26·9
Brachiaria + Centrosema	39·6	15·2
2nd Cut		
Brachiaria + Alysicarpus	41·8	30·8
Brachiaria + Centrosema	44·1	28·4
3rd Cut		
Brachiaria + Alysicarpus	42·6	41·1
Brachiaria + Centrosema	37·3	32·9

4——R 4960 (9/62)

A major change which was caused by the application of nitrogen was a marked reduction in the proportion of legumes from the flora. In the first cut following the application of fertilizer nitrogen, the legumes were suppressed to a significantly greater extent than in the subsequent cuts. The decreased percentage of legumes following fertilizer application is largely due to the vigorous and rank growth of grasses.

(*b*) *Influence of phosphates on botanical composition.* Table 2 shows the influence of phosphate on the percentage legume content of the pasture.

The proportion of legumes was unaffected by the application of phosphate in the first harvest, but in the 2nd and 3rd harvests, the presence of phosphate showed an increase in the legume content.

TABLE 2.—Effect of phosphates on per cent. legume content of the pasture (on dry weight basis)

	p_0	p_1	p_2
1st Cut			
Brachiaria + Alysicarpus ..	40·9	37·2	42·0
Brachiaria + Centrosema ..	26·3	33·5	22·5
2nd Cut			
Brachiaria + Alysicarpus ..	32·8	37·5	38·7
Brachiaria + Centrosema ..	25·2	49·8	33·8
3rd Cut			
Brachiaria + Alysicarpus ..	39·1	47·5	39·4
Brachiaria + Centrosema ..	23·7	44·1	37·6

2. Yields of Dry Matter

THE overall effect of legumes and fertilizers on the total accumulative yield of pasture herbage is shown in Table 3. The data show a statistically significant response to legumes and nitrogen application.

TABLE 3.—Effect of legumes and fertilizers on the total yield of dry matter lb. per acre

	N_0			N_1			*Mean*
	P_0	P_1	P_2	P_0	P_1	P_2	
Brachiaria alone ..	4623	4740	5831	7152	6489	6954	5965
Brachiaria + Alysicarpus ..	9303	9787	9242	9746	10381	12059	10086
Brachiaria + Centrosema ..	9086	9073	8579	8754	10491	9692	9279

L. S. D. .. N effect = 336 Legume effect = 412

It will be seen that the yield of pasture herbage was greatly increased by the inclusion of a legume. Brachiaria brizantha grown alone gave an average yield of 5,965 lb./acre, whereas Brachiaria brizantha grown with Alysicarpus and Centrosema yielded 10,086 lb. and 9,279 lb./acre respectively.

As might be anticipated, Nitrogen top dressings gave increased yields of dry matter in the 1st cut following the application of Nitrogen, but in the subsequent cuts the effect of nitrogen was virtually lost, thus supporting the contention that when herbage is cut and removed from the field, further growth depends upon fresh supplies of available nitrogen.

Although in a number of cases where phosphates applications were made in the presence of nitrogen, an increase in yield was apparent, in no case could these increases be regarded as significant.

3. Chemical Composition of Pasture herbage

(*a*) *Percentage protein in dry matter.* The results shown in Table 4, indicate the influence of legumes and fertilizer nitrogen on the protein content of grass alone and grass grown in association with legumes.

TABLE 4.—Effect of legumes and fertilizer nitrogen on the percentage protein in dry matter

	N_0	N_1
1st Cut		
Brachiaria alone	5·42	6·19
Brachiaria + Alysicarpus	9·84	8·22
Brachiaria + Centrosema	11·54	6·68
2nd Cut		
Brachiaria alone	5·26	4·61
Brachiaria + Alysicarpus	8·36	6·37
Brachiaria + Centrosema	11·48	7·88
3rd Cut		
Brachiaria al ne	3·74	3·81
Brachiaria + Alysicarpus	6·44	6·36
Brachiaria + Centrosema	7·37	6·35

Apart from revealing the increase in crude protein content of dry matter, following the application of fertilizer nitrogen, an effect which has been demonstrated previously (3, 4), these results showed a significant increase in crude protein due to the presence of legumes in all 3 harvests. This increase was masked to a significantly greater

extent only in the presence of nitrogen. Centrosema pubescens almost invariably gave higher contents of crude protein than Alysicarpus, due no doubt to the better nutritive value of the former.

It appears therefore, that the changes in the protein content of herbage following fertilizer treatment, are also associated with changes in the botanical composition of the sward.

(*b*) *Percentage CaO and fat in dry matter.* The effect of legumes and nitrogen on the CaO and fat contents of herbage is shown in Table 5.

TABLE 5.—Effect of legumes and nitrogen on the per cent. CaO and fat in dry matter

		N_0	N_1
1st Cut			
Brachiaria alone	CaO	0·69	0·62
	Fat	1·70	1·96
Brachiaria + Alysicarpus	CaO	1·22	0·93
	Fat	2·12	1·73
Brachiaria + Centrosema	CaO	1·04	0·69
	Fat	2·43	1·87
2nd Cut			
Brachiaria alone	CaO.. ..	0·69	0·70
	Fat	1·60	1·45
Brachiaria + Alysicarpus	CaO	1·45	1·11
	Fat	1·74	1·55
Brachiaria + Centrosema	CaO	1·26	1·09
	Fat	2·06	2·02

In every case the presence of a legume resulted in an increased CaO and fat contents in dry matter, the increase being directly related to the increase in the proportion of legumes. Nitrogen fertilizer in itself, had no direct effect in the pure grass plots, but through a suppression of legumes in the mixed sward, it indirectly resulted in a reduced CaO and fat content. Without legumes the CaO and fat contents of herbage were constant at both levels of nitrogen.

(*c*) *Effect of phosphates on the P_2O_5 content of herbage.* The presence or absence of phosphates had little influence either on the protein, CaO or fat contents, but its presence however, can be relied on to enhance the P_2O_5 content of the herbage as seen in Table 6.

TABLE 6.—Effects of phosphates on the per cent. P_2O_5 content of herbage

	P_0	P_1	P_2
1st Cut			
Brachiaria alone ..	0·28	0·45	0·42
Brachiaria + Alysicarpus ..	0·36	0·37	0·42
Brachiaria + Centrosema ..	0·30	0·45	0·44
2nd Cut			
Brachiaria alone ..	0·47	0·58	0·55
Brachiaria + Alysicarpus ..	0·37	0·40	0·44
Brachiaria + Centrosema	0·38	0·38	0·52

The results discussed so far, seem to indicate that practices connected with management for high pasture production are dominated by nitrogen and there is little doubt about the contribution that legumes can make to increase production. The nitrogen fertilizer may also play a major role in increasing grassland production but its application depends largely on the conditions under which its use can be made profitable. Although the addition of nitrogen increases both the nutritive value and tonnage, it is only temporarily. The legumes on the other hand, exert a more pronounced and a permanent effect.

PART II

The final evaluation of a pasture's productivity must be through the animal itself.

The objects of this experiment were—

(1) To ascertain the contribution made by legumes in terms of animal production, as measured by the live-weight gains of cattle.

(2) To study the effects of different pasture types and their component species on the nutritive valve of herbage.

(3) To ascertain the compatibility and persistence of legumes grown in association with Brachiaria brizantha, under grazing conditions.

Experimental

THREE pasture types consisting of Brachiaria brizantha with and without legumes were each replicated four times. The legumes used in this trial were Pueraria phaseoloides and Centrosema pubescens. The legumes were sown in rows 3 ft. apart at a seed rate of 6 lb./acre

and Brachiaria was planted at a distance of 3 x 3 feet. The pastures were grazed on a rotational basis at a stocking rate of two (2 yr. old) animals per acre. The size of each plot was half-acre.

Representative samples for chemical analyses from each pasture type were taken before the animals had access to a new pasture. In addition, a sub-sample of 400 g. from the mixed pastures was hand separated into their component species.

RESULTS AND DISCUSSION

(*a*) *Live-weight gains.* The increased live-weight production, resulting from the inclusion of legumes can be seen in Table 7. The average gain for the 260 day period was 414,578 and 564 lb./acre for grass alone, Pueraria/grass and Centrosema/grass, respectively. This represents an increased yield of 164 and 150 lb./acre, in favour of Pueraria and Centrosema pastures respectively.

TBALE 7.—Effects of legumes on live-weight gains of Cattle

	Brachiaria alone	*Brachiaria/ Pueraria Association*	*Brachiaria/ Centrosema Association*
Number of days	260 ..	260 ..	260
Stocking rate (animals'acre) ..	2 ..	2 ..	2
Gain per animal per day (lb.) ..	0·79 ..	1·11 ..	1·08
Gain per head (lb.)	207 ..	289 ..	282
Gain per acre (lb.)	414 ..	578 ..	564

Fig. I shows the growth curves for each pasture type. The superiority of the mixed pasture over the grass in pure stand is clearly demonstrated.

(*b*) *Effect of different pasture types and their component species on the nutritive value of herbage.* The influence of legumes and their association with Brachiaria brizantha on the chemical composition is indicated in Table 8.

TABLE 8.—Influence of legumes on the nutritive value of herbage (mean of 15 Rotation Cycles)

Percentage of Dry Matter	*Br. Alone*	*Brachiaria/Pueraria Association*			*Brachiaria/Centrosema Association*		
		Pueraria	*Brachiaria*	*Mixed Pasture*	*Centro-sema*	*Brachia-ria*	*Mixed Pasture*
Protein ..	5·99	17·38	10·03	13·34	18·96	7·38	11·12
Fibre ..	30·34	30·19	31·15	30·52	29·93	31·25	31·48
Ash ..	9·19	9·49	9·43	9·32	8·51	9·06	9·19
Fat ..	1·81	2·79	2·22	2·70	2·91	1·97	2·30
CaO ..	·51	1·80	·75	1·37	1·92	·67	·97
P_2O_5 ..	·41	·3	42	·39	·35	·47	·44

As may be expected, the overall quality of the mixed pasture was greatly improved, while the grass in pure stand had the lowest average quality. It may also be observed that the increased quality of herbage in the mixed pasture is partly due to the higher nutrive value of the legumes and partly to the high nutritive value of grass grown in association with the legumes. The results shown in Table 9 add further support to this view.

TABLE 9.—Percentage Protein content on dry matter of grass grown in Association

Date	*Grass in pure stand*	*Grass grown with Pueraria*	*Grass grown with Centrosema*	*L. S. D.*
9.12.60	6·12	9·45	6·09	—
2. 1.61	7·68	9·30	5·41	—
16. 1.61	5·01	9·21	7·42	—
13. 2.61	6·54	9·03	8·63	—
27. 2.61	8·67	11·17	8·25	—
13. 3.61	4·93	8·28	8·44	—
27. 3.61	6·08	12·83	6·81	—
10. 4.61	6·72	11·23	9·50	—
24. 4.61	6·31	11·33	8·50	—
8. 5.61	6·11	9·79	9·09	—
22. 5.61	6·56	11·41	7·20	—
5. 6.61	8·27	11·29	6·68	—
12. 6.61	3·48	11·79	7·86	—
3. 7.61	3·51	4·78	4·41	—
17. 7.61	3·95	9·64	6·35	—
Mean	5·99 ..	10·03 ..	7·38 ..	1·23

A noteworthy feature is that the protein content of the grass in pure stand averaged 5.99 per cent, whereas the same grass grown in association with Pueraria and Centrosema averaged 10.03 per cent and 7.38 per cent respectively. This suggests that the enhanced protein content of the associated grass may have been due to a transference on Nitrogen from the activity growing legumes. Of the two legumes, Pueraria appears to be a better Nitrogen fixer than Centrosema pubescens.

(c) *Compatibility and Persistence of legumes under grazing conditions.* The regrowth of both Pueraria and Centrosema after grazing, has been rapid and their creeping habit has led to an easy association with Brachiaria brizantha. Both legumes behaved similarly in terms of nutritive value and livestock production. Pueraria may have been more productive but under the hard grazing conditions imposed in this trial, Centrosema appears to be more persistent and it should be particularly useful for dry season grazing. Pueraria is very sensitive to close grazing. A system of high grazing will favour the Pueraria and short grazing, the grass.

SUMMARY

THE performance of three legumes, viz. Pueraria phaseoloides, Centrosema pubescens and Alysicarpus vaginalis, when grown in association with the grass Brachiaria brizantha, was investigated in two field experiments under grazed and ungrazed conditions.

It was found that the dry matter yield in the grass-legume mixture was significantly superior to that of grass in pure stand. Nitrogen application caused a reduction in the proportion of legumes in the grass-legume sward, but increased the protein status in the pure grass sward. The reduction in the legume component in the grass-legume sward was also accompanied by a marked decline in the percentage protein, calcium oxide and fat contents.

Quality of herbage was greatly improved in the presence of a legume. Chemical analysis revealed an increase in the protein content of the grass component in the grass-legume sward.

During a 260 day experimental period it was found that animals grazing on a grass-legume pasture gained 150 lb. beef per acre over the animals grazing on grass alone. Mean daily live weight gains per animal were 1.11 lb., 1.08 lb., and 0.80 lb. respectively for Pueraria grass, Centrosema grass and grass alone respectively.

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5—R 4960 (9/62)

Pueraria/Brachiaria association

Centrosema/Brachiaria association

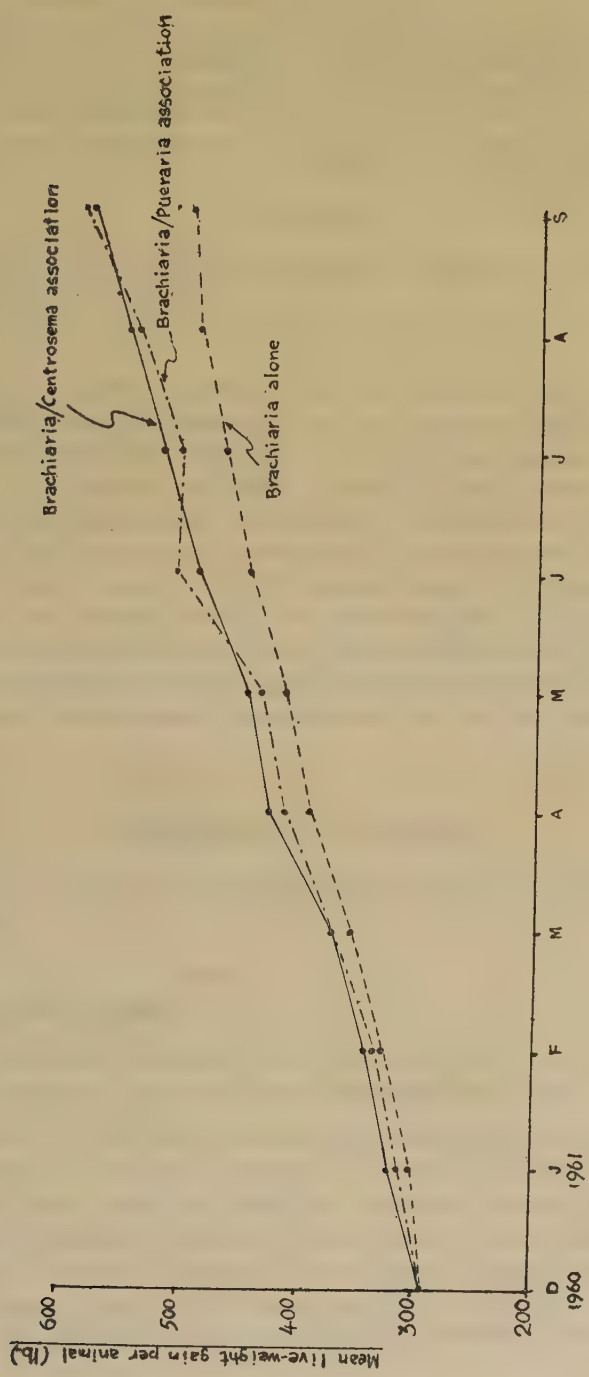

Fig. 1—Growth curves for different pasture types.

STUDIES ON THE ROOTSTOCKS FOR MANDARINS IN THE WET SUB-TROPICS. II. (VARIETY SRINAGAR)

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Selection of suitable rootstocks for the commercial varieties of sweet oranges and mandarins for wet sub-tropical zones with high temperatures is a major problem, on which no systematic work has been done. The author initiated a series of such trials on sweet oranges and mandarins, and the results of three sweet orange scion varieties and Hill mandarin have already been reported (5, 6, 7, 8). The present paper deals with the performance of Srinagar variety of mandarins on Florida Rough, Jambheri, Italian 76, Seville orange, Sweet lime, Lime Sylhet and Karna Khatta rootstocks. The review of literature, materials and methods, and pomological descriptions of the rootstocks have already been detailed in the first paper of the series (5).

EXPERIMENTAL FINDINGS

THE growth records for the years 1957 to 1961 are presented below variate-wise.

1. Circumference of stock

The stock girth measurements were recorded at a fixed point just below the bud-union, and the data is presented in Table I.

It is apparent from Table I that Florida Rough stock was significantly superior to Jambheri, Seville orange, Sweet lime and Lime Sylhet stocks throughout the period at 5 per cent level of probability. Although no significant differences were found over Italian 76 and Karna Khatta stocks, Florida Rough gave better stock girth throughout except during 1958, when Italian 76 proved to be slightly superior to it. Seville orange consistently possessed the minimum stock girth throughout and was preceded by Sweet lime stock.

Italian 76, except during 1958, was next to Florida Rough and was followed by Karna Khatta. During 1958, 1960 and 1961, Jambheri was superior to Lime Sylhet, which gave higher girth than Jambheri during 1957 and 1959.

2. Circumference of scion

THE data for scion-girth in centimeters is presented in Table II. It is evident from Table II that Srinagar trees on Seville orange stock possessed the minimum scion girth and were closely preceded by those on Sweet lime stock. During 1959, trees on Florida Rough gave the maximum scion girth, whereas those on Italian 76 excelled all others during 1957, 1958, 1960 and 1961, and the results were significant over Jambheri, Seville orange, Sweet lime and Lime Sylhet stocks at 5 per cent level of probability. Karna Khatta was consistently the third in order of merit and Lime Sylhet was ranked fourth during 1957, 1960 and 1961 but Jambheri proved to be superior during 1958 and 1959.

3. Volume of the tree

THE volume of the trees was computed in cubic meters according to the method detailed in the first paper of the series (5) and the values are given in Table III. A perusal of Table III shows that for this variate, Italian 76 excelled all other rootstocks, whereas Srinagar scion on Seville orange consistently possessed the minimum volume. Florida Rough was second in order of merit and was followed by Karna Khatta. Lime Sylhet except during 1958 and 1959 was better than Jambheri, which was followed by Sweet lime. During 1958 and 1959, Jambheri proved to be superior to Lime Sylhet stock. The results with Italian 76 stock were significantly superior to Jambheri, Seville orange, Sweet lime and Lime Sylhet during 1957 and 1958 and to all other rootstocks excepting Florida Rough, during 1959, 1960 and 1961.

4. Scion-stock ratio

THE scion-stock girth ratios as calculated from Tables I and II are compiled in Table IV. From a close study of Table IV it would appear that during 1959, 1960 and 1961 all the rootstocks under study, viz., Jambheri, Florida Rough, Sweet lime, Seville orange, Lime Sylhet, Karna Khatta and Italian 76 gave compatible unions as judged from the suggested interpretations of physical index of compatibility

by the author (5). Jambheri, Florida Rough, Seville orange and Lime Sylhet during 1957, and Jambheri, Seville orange and Lime Sylhet during 1958, however, gave only good combinations, while the rest were interpreted to be excellent ones. It was interesting to note that Italian 76 gave the best values throughout except during 1957 and Seville orange consistently the least. Sweet lime showed highest value of the ratio during 1957 only.

TABLE I.—Average girth of rootstocks per tree in cms.

Rootstocks	*Girth per tree in cms. recorded during*				
	1957	*1958*	*1959*	*1960*	*1961*
Jambheri	23·0	27·6	28·3	35·6	38·9
Florida Rough	30·8	35·3	40·3	46·3	49·7
Seville orange	13·5	16·8	21·0	25·0	29·3
Sweet lime	17·5	21·7	24·7	28·4	31·6
Italian 76	29·3	35·5	39·3	44·7	48·9
Lime Sylhet	23·1	26·1	29·7	35·4	38·2
Karna Khatta	27·3	31·6	35·7	40·5	43·8
S. E.	3·09	3·05	3·74	4·23	5·12
C. D. at 5%	6·2	6·1	7·5	8·5	10·3

TABLE II.—Average girth of Srinagar scions per tree in cms. on different rootstocks

Rootstocks	*Girth of Srinagar scion in cms. recorded during*				
	1957	*1958*	*1959*	*1960*	*1961*
Jambheri	18·4	23·3	27·7	31·7	34·9
Florida Rough	26·0	31·6	37·0	41·9	45·4
Seville orange	10·2	13·7	18·3	22·0	25·8
Sweet lime	16·1	19·1	22·3	26·2	29·3
Italian 76	26·4	31·9	36·7	42·0	46·2
Lime Sylhet	19·2	22·1	27·0	32·5	35·6
Karna Khatta	24·7	28·2	32·3	37·2	40·4
S. E.	2·81	2·93	3·08	3·04	3·75
C. D. at 5 %	5·7	5·9	6·2	6·1	7·5

TABLE III.—Average volume per Srinagar tree on different rootstocks in cubic meters

Rootstocks	*Volume per tree in cubic meters recorded during*				
	1957	*1958*	*1959*	*1960*	*1961*
Jambheri	9·38	20·58	24·95	47·63	57·86
Florida Rough	20·38	39·57	49·18	76·14	105·75
Seville orange	1·99	7·43	10·42	20·31	37·34
Sweet lime	6·54	12·53	15·33	29·77	38·09
Italian 76	22·01	41·99	56·21	95·10	124·31
Lime Sylhet	11·63	19·58	24·81	55·59	65·49
Karna Khatta	16·96	33·71	42·53	71·22	94·09
S. E.	3·20	5·23	6·40	11·44	12·96
C. D. at 5 %	6·49	10·62	12·99	23·12	26·19

TABLE IV.—Scion/ Stock girth ratio of Srinagar on different rootstocks

Rootstocks	*Scion stock ratio of girths recorded during*				
	1957	*1958*	*1959*	*1960*	*1961*
Jambheri	0·80	0·84	0·89	0·89	0·90
Florida Rough	0·84	0·90	0·92	0·90	0·91
Seville orange	0·76	0·82	0·87	0·87	0·88
Sweet lime	0·92	0·88	0·90	0·92	0·93
Italian 76	0·90	0·90	0·93	0·94	0·94
Lime Sylhet	0·83	0·85	0·91	0·91	0·93
Karna Khatta	0·90	0·89	0·90	0·91	0·92

5. Fruit yield

THE average number of fruits borne on a tree for each treatment was recorded year-wise from 1957 and the data are summarised in Table V. Table V presents some very interesting trends in the fruit yield of Srinagar on different rootstocks under study. During 1957, Karna Khatta gave the highest yields which were significantly superior to the yields on Jambheri and Seville orange. Italian 76, Florida Rough, Lime Sylhet, Sweet lime, Jambheri and Seville orange followed these yields in the descending order. Italian 76 stock proved to be superior over all others during 1958 and was followed by Florida Rough, Lime Sylhet, Karna Khatta, Jambheri, Seville orange and Sweet lime in order. Trees on Karna Khatta again gave the highest yields during 1959. The average yields during 1958 and 1959 were on the whole exceptionally low probably due to heavy wind storms in the month of April and similar trend was recorded with the other varieties reported earlier (5, 6, 7, 8). During 1960, Italian 76 again surpassed all other stocks and was followed by Karna Khatta, Lime Sylhet, Florida Rough, Jambheri, Seville orange and Sweet lime. The yields on this stock were significantly superior to those on Jambheri, Seville orange and Sweet lime stocks.

The entire trend of cropping was reversed during 1961, which was considered to be the commercial cropping year. Lime Sylhet, so far a moderate bearing stock, recorded the highest yields over all other stocks and the results were significant at 5 per cent level of probability over Jambheri, Seville orange and Sweet lime stocks. Florida Rough, Italian 76, Karna Khatta, Jambheri, Seville orange and Sweet lime were ranked in the descending order. During this year, besides counting the number of fruits the total weight of the fruits in kilograms was also recorded. Trees on Lime Sylhet stock gave the maximum yields in weight followed by Florida Rough, Karna Khatta, Jambheri, Italian 76, Seville orange and Sweet lime. The average individual fruit size was found to be the largest on Florida Rough and was followed by Jambheri, Lime Sylhet, Seville orange, Karna Khatta, Sweet lime and Italian 76.

6. Fruit quality

UNDER the physico-chemical analysis, the percentage of juice and of rag and peel, vitamin C content and T. S. S./Acid ratio were determined as detailed in the earlier paper (5). The data for different constituents are presented in Table VI.

(*a*) *Percentage of juice*: The highest juice percentage was found in Srinagar fruits on Lime Sylhet stock and was followed by those on Karna Khatta, Jambheri, Florida Rough, Italian 76, Sweet lime and Seville orange stocks.

(*b*) *Percentage of peel and rag*: Fruits on Seville orange gave the maximum percentage of peel and rag, whereas those on Lime Sylhet, the least. These values were, however, supplementary to those for the percentage of juice.

(*c*) *Vitamin C content.* Determinations of vitamin C content was done by direct titration of juice against 2, 6 dichloroindo-phenol and expressed as mgm. per 100 gms. of juice. 24.0 mgm. of vitamin C were estimated in Srinagar fruits on Lime Sylhet stocks while Karna Khatta, Sweet lime and Florida Rough gave 23.0, 22.0 and 20.0 mgs./100 gms. of juice. The values for Italian 76, Seville orange and Jambheri were 18.0, 17.0 and 15.0 mgm. per 100 gms. of juice, respectively.

(*d*) *T. S. S./Acid ratio.* The acidity was the highest in the fruits of Srinagar on Lime Sylhet stock followed by those on Florida Rough. Italian 76 and Karna Khatta had the same values and followed Florida Rough. Lowest acidity was found in fruits on Seville orange stock and was preceded by Jambheri and Sweet lime stocks, which had identical values.

The total soluble solids as determined by a hand refractometer were found to be 10 per cent in Florida Rough, Sweet lime, Italian 76, Lime Sylhet and Karna Khatta. The values for Jambheri and Seville orange stocks were recorded to be 9 per cent. The maximum T. S. S./Acid ratio was found in fruits on Seville orange stock followed by Sweet lime, Italian 76 and Karna Khatta, Florida Rough, Jambheri and Lime Sylhet stocks.

TABLE V.—Average yield of Srinagar fruits per tree on different rootstocks

Rootstocks	*Average yield in number of fruits during*					*Average yield of fruits during 1961*	
	1957	*1958*	*1959*	*1960*	*1961*	*Wt. in kg. per tree*	*Wt. in gm. per fruit*
Jambheri	57·0	44·0	29·7	138·2	94·3	12·25	129·9
Florida Rough	102·0	59·0	33·7	205·5	133·7	19·07	142·6
Seville orange	23·0	19·0	5·2	120·3	86·2	10·52	122·0
Sweet lime	80·0	14·3	13·3	106·2	70·6	7·35	104·1
Italian 76	108·3	71·3	31·6	229·3	119·7	12·21	102·0
Lime Sylhet	94·3	54·3	21·9	206·3	156·3	19·68	125·9
Karna Khatta	125·0	45·3	36·4	223·3	114·8	13·91	121·2
S. E.	26·0	17·5	10·3	35·2	28·5		
C. D. at 5 %	52·5	35·4	20·8	71·1	57·6		

TABLE VI —Analysis of Srinagar fruits obtained from different rootstocks during 1961

Characters	*% of juice*	*% of Rag and Peel*	*% of acidity*	*Total soluble solids*	*T. S.S./ Acid ratio*	*Vitamin C mgm. 100 gms. of juice*
Rootstocks						
Jambheri	42·3	56·8	·8750	9	10·3	15·0
Florida Rough	42·1	56·9	·9450	10	10·6	20·0
Seville orange	36·9	62·0	·7350	9	12·2	17·0
Sweet lime	38·4	60·7	·8750	10	11·4	22·0
Italian 76	40·2	58·5	·9100	10	11·0	18·0
Lime Sylhet	46·1	52·8	·9975	10	10·0	24·0
Karna Khatta	45·4	53·7	·9100	10	11·0	23·0

7. Incidence of diseases and deficiency symptoms

THE visual assessment of collar rot, zinc deficiency and winter chlorosis symptoms was done and is detailed below:

(*a*) *Collar rot disease.* Lime Sylhet and Seville orange stocks were observed to be fairly susceptible to this disease. Florida Rough, Italian 76 and Sweet lime were found to be quite resistant, whereas Karna Khatta and Jambheri stocks were ranked moderately resistant to this disease.

(*b*) *Zinc deficiency.* Almost all Srinagar trees on different rootstocks under the trial showed the interveinal chlorosis, although the extent of symptoms varied considerably. The plants on Florida Rough and Italian 76 were observed to show the minimum symptoms of zinc deficiency, while the trees on Lime Sylhet and Jambheri had pronounced symptoms. Seville orange, Sweet lime and Karna Khatta stocks had moderately pronounced symptoms.

(*c*) *Winter chlorosis.* Yellowing of leaves with veinal chlorosis was termed as winter chlorosis. Srinagar trees on Florida Rough and Karna Khatta were observed to have the least symptoms of this malady, whereas the trees on Lime Sylhet and Sweet lime had the most pronounced symptoms.

DISCUSSION AND CONCLUSION

THE present investigations reveal that Florida Rough excelled all other rootstocks, viz., Jambheri, Lime Sylhet, Seville orange, Italian 76, Sweet lime and Karna Khatta, in an overall assessment of their merits and de-merits for Srinagar scion variety of mandarins. The trees on this stock were maximum in stock girth, gave the largest sized fruits and were quite resistant to collar rot, zinc deficiency and winter chlorosis disorders. In scion girth and volume, the trees were second to those on Italian 76, whereas the yields were second only to those on Lime Sylhet stocks. However, this rootstock produced fruits of an average good quality as determined by physico-chemical analysis.

Karna Khatta was second in order of merit and had high juice percentage and vitamin C content, next only to those on Lime Sylhet. It produced trees of average vigour with average yields, fruit size and T. S. S./Acid ratio. The stock was moderately resistant to collar rot, zinc deficiency and winter chlorosis.

The trees on Lime Sylhet were rather moderate in vigour and produced highest yields with maximum juice percentage and vitamin C content. However, the fruits on this stock were lowest in T. S. S./Acid ratio and plants were very susceptible to collar rot, zinc deficiency and winter chlorosis.

Italian 76 proved to be superior to Jambheri in vigour, yield, T. S. S./Acid ratio and resistance to collar rot, winter chlorosis and zinc deficiency. The plants on Jambheri bore fruits of largest size next only to Lime Sylhet with average good quality.

Seville orange was observed to be the most inferior stock for Srinagar variety of mandarins and was preceded by Sweet Lime. The trees on Seville orange were poorest in vigour, juice percentage, yield and vitamin C content next only to Lime Sylhet stocks. Surprisingly enough the fruits on Seville orange had the best T. S. S./Acid ratio. Sweet lime stock gave the lowest yield with trees of poor vigour, fruit size, juice percentage and fair susceptibility to collar rot, zinc-deficiency and winter chlorosis.

Bhattacharya and Dutta (1) reported that Soh-myndong and Kata jamir (both *Citrus jambhiri*) were perfectly compatible with Khasi mandarins. Soh-sarkar (*C. karna*), however, produced normal trees but declined in later stages. The present results of Srinagar on Florida Rough support the conclusions of these workers with regard to their performance on *Citrus jambhiri* but differ with the performance of Karna Khatta. The performance of Srinagar scion on Karna Khatta was the second best and the trees were very healthy and vigorous. The performance of *C. jambhiri* as a suitable rootstock is supported by the performance of Hill variety of mandarin on Italian 76 and Florida Rough (8) and also by the results reported by various other workers (4, 9, 10).

Sour orange has been reported to be a poor rootstock by Dass (3), Phadnis (4) and Bhattacharya and Dutta (1) for mandarins. The present results with the Srinagar scion and those of Hill variety of mandarin reported earlier (8) are in full consonance with the results of these workers. The performance of Sweet lime rootstock with Srinagar variety of mandarin does not tally with the results of Brown

Table VII.—Showing the randing of different rootstocks for various characters

Characters	*Stock girth*	*Scion girth*	*Volume*	*Yield*	*Fruit size*	*Juice per cent.*	*Vitamin 'C'*	*T. S. S. Acid Ratio*	*Collar rot*	*Zinc Deficiency*	*Winter Chlorosis*
Jambheri	4	3	3	3	6	5	1	2	6.5	2	2
Florida Rough	7	6	6	6	7	4	4	3	5	6.5	7
Seville orange	1	1	1	2	4	1	2	7	1.5	3	3
Sweet lime	2	2	2	1	2	2	5	6	3	4	2
Italian 76	6	7	7	5	1	3	3	4.5	4	6.5	5
Lime Sylhet	3	4	4	7	5	7	7	1	1.5	1	1
Karna Khatta	5	5	5	4	3	6	6	4.5	6.5	5	6

(2) who reported Sweet lime to be the best rootstock for Sangtra. The present results find their support, also, from those of Hill variety reported by the author (8).

The comparative merits and de-merits of different rootstocks for Srinagar scion are summarized in Table VII. The performance of Srinagar on Florida Rough was found to be outstanding in the present studies. Karna Khatta occupied the second position while Seville orange gave the most unsatisfactory results.

SUMMARY

1. The performance of mandarin variety Srinagar was studied on Jambheri, Florida Rough, Seville orange, Sweet lime, Italian 76, Lime Sylhet and Karna Khatta rootstocks at the Horticultural Research Institute, Saharanpur.

2. Florida Rough was found to be the outstanding rootstock for the variety under study. Vigorous plants with high yields, large sized fruits and of good resistance to collar rot, zinc deficiency and winter chlorosis were the main qualities of this stock.

3. Karna Khatta was next to Florida Rough and produced fruits of high juice percentage and vitamin C content.

4. Seville orange, Sweet lime and Jambheri proved to be the inferior stocks while Lime Sylhet and Italian 76 were ranked average ones.

Under the wet sub-tropics with high temperatures, Florida Rough is recommended as the optimum stock for Srinagar variety of mandarin.

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THE CENTENARY OF THE BOTANIC GARDENS, HAKGALA, 1861-1961

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The year 1961 was a milestone in the history of the Botanic Gardens of Hakgala, for this year it celebrated its Centenary. To commemorate this event, on the 19th April 1961, the Hon'ble Minister of Agriculture, Lands, Irrigation and Power, Mr. C. P. de Silva, planted a Camphor seedling in the Gardens.

Started in the year 1861 as an experimental station for Cinchona cultivation, it is, today, a Botanic Garden of repute, with a wealthy collection of temperate and sub-tropical plants. During the early part of its history this garden had been the trial grounds not only of some of the important crops which effect the economy of this island even to this day, but also of a large number of trees and shrubs now fully acclimatised and naturalized in the hill country.

Nestled among the forest clad hills of Ceylon, in an atmosphere and climate all its own, lie the gardens. It is situated seven miles South east of Nuwara Eliya at an elevation of 5581 feet above sea level in surroundings deeply connected in mythology—for it is said that it was in this very locality where the present Gardens lie, that Ravana, a warrior king of Ceylon, hid the beauteous Orient Queen Sita, wife of Rama. This epic love story is related in the classic, Ramayana. It is fitting then, to find a garden in this vicinity shrouded in Romance.

The gardens facing East gets its name from the towering rocky mountain behind it—Hakgala—so called because of its shape, the three peaks resembling a molar and appropriately named Hakgala, in Sinhalese meaning molar rock. The highest of the peaks is over 7000 feet above sea level and at the foot of this rocky mountain spread the Botanic Gardens.

The Garden has a mean rainfall of 95 inches falling on an average of 210 days. The mean temperature is 60°F, the lowest and highest temperatures being approximately 38°F and 82°F respectively. From

the middle of May to August the gardens face the full blast of the South West Monsoon which comes rolling down the precipitous Hakgala mountain and sweeps down upon the gardens making most of the trees have an unmistakably one-sided appearance. And in the North East Monsoon which prevails from about December to February or March the Gardens are enfolded in a thick mist so harmful to plant life and temperatures drop low. One is apt to wonder why then this place wa chosen for a garden. The history of the gardens answers this question.

In 1859 India tried to procure seeds of the quinine producing plant Cinchona calisaya from South America. Dr. Cleghorn, Conservator of Forests of the Madras Presidency had talks with the Director of the Royal Botanic Gardens, Peradeniya, Dr. G. H. K. Thwaites, regarding the introduction of Cinchona into the hill country of this island. An experimental garden for this purpose and for trying out exotics such as conifers, ornamental trees and even tea, was considered essential. A Botanic Garden not far from Nuwara Eliya was thought would also add interest to this Sanatorium in the hills with its cool climate. Thus was born the idea of an Experimental Garden.

Dr. Thwaites then, in 1860, selected a piece of land for this purpose, in particular for trials on the quinine producing Cinchona. Mr. (Later Sir) Clements Markham had collected plants from South America and was bringing them over to India. Mr. Markham's plants did not travel well and none were sent to Ceylon. Ceylon therefore got no growing Cinchona plants from Mr. Markham's mission to South America. But seeds of Cinchona micrantha and Cinchona nitida, collected by Mr. Pritchett in South America were received by Dr. Thwaites in 1861 from Mr. Mac Ivor of the Government Cinchona plantations in Neilgherries through the Chief Secretary to Government Fort St. George. Soon after this, seeds of Cinchona succirubra collected by Mr. Spruce were received in Ceylon through the Secretary of State's office. From these seeds a large number of plants were raised. These then were the first plants of Cinchona in this Island and they were planted in Hakgala in the year 1861, " in the plateau under the rock summit of Hakgala, because of the general resemblance of the natural features to those which distinguish the habitat of the Cinchona in the Andean ranges ". It was for this reason that the present site was chosen, originally, as an Experimental Garden.

Mr. W. Mac Nicoll, from the Royal Botanic Gardens, Kew, was placed in charge of the Hakgala Garden. In late 1861 six plants of Cinchona calisaya were sent from Kew through Dr. J. Anderson of the Calcutta Botanic Gardens and of these, only two survived the

journey and grew vigorously at Hakgala. From the Hakgala plants Mr. Mac Nicoll obtained rooted cuttings and soon this garden undertook to distribute plants to Estates at different elevations for experimental planting of Cinchona. Under the zeal and care of Mr. Mac Nicoll the Cinchona plants progressed well. The larger plants were set out in areas cleared for this purpose. Some trees were allowed to grow freely, produce flowers and set seed while from others, cuttings were taken for easy propogation and rapid distribution.

In the succeeding years Hakgala became an important distribution centre for Cinchona seeds, plants and rooted cuttings not only to the numerous Estates in the hill country, but seeds were also sent to India, Australia, China, Java, Mauritius, Borneo and to the Royal Botanic Gardens, Kew. Numerous species of Cinchona were introduced to Hakgala. Cinchona officinalis, a species which was easily propogated, thrived well on land too high for Coffee cultivation and therefore proved very successful. A large number of Estates took to cultivation of Cinchona and they even started their own nurseries. The money market around 1865-1868 was however in an unfavourable state and planting was not carried out to the extent expected, although copious supplies of seeds and cuttings were available for distribution.

Around 1865 the prospect of launching on TEA was started. Here too Hakgala played an important role and tea was planted for distribution of seeds and plants as was done with Cinchona. By 1869 tea was growing vigorously at Hakgala. The common China Bohea tea seeds were available for planting both at Hakgala and at Peradeniya while the Assam and Assam Hybrid tea seeds were also available at Hakgala where they thrived exceedingly well. In the 1870 Report of the Director of Gardens, Dr. Thwaites, on the subject of Tea, wrote "the tea plant thrives so luxuriantly upon hills at an elevation slightly above that suited for coffee cultivation that it is difficult not to believe that their slopes will, before very long, be covered with thriving tea plantations" and in the 1871 Report he wrote "I would strongly recommend trials being made of this hardy plant (tea) on abandoned coffee estates rather than that weeds should be allowed to take possession of the land. There can hardly be a doubt that the expense of such a step would be more than repaid, if tea is one day

Fernery at Hakgala showing giant tree ferns

Rose Garden—Hakgala

to become, as it most probably will, one of the most important staple products of the island". It was at this time, around 1871 that the coffee leaf disease took a huge toll of a large number of coffee plants and it was Dr. Thwaites that predicted the fall of Coffee and the rise of Tea.

In the History of Hakgala the eighteen seventies saw the gradual rise of Cinchona and Tea. Although many new species of Cinchona were available at Hakgala, only Cinchona succirubra and C. officinalis were the species grown extensively by planters and Hakgala was responsible for the distribution of these plants. In 1874, for example, 826,000 Cinchona plants were distributed while in 1876 the figure was 1,200,000. Cinchona bark from Ceylon fetched good prices and its cultivation expanded. About 1875 it was also established that commercial tea of a very superior quality could be produced in Ceylon and so "tea plantations rapidly made themselves visible in the upper portions of many of the hills of the Central Province". Tea planters were interested in improving both plants and methods of manufacture of the leaves. More and more acres were being brought under tea, at different elevations while larger quantities of manufactured tea were leaving the shores of Ceylon into foreign markets.

By the commencement of the next decade Cinchona and tea were both fully established and Hakgala's usefulness as a distribution centre for Cinchona plants ceased. At this time Hakgala had a change in the administration when William Nock, Superintendent of Cinchona Plantations in Jamaica took charge.

With William Nock as Superintendent of Hakgala and Dr. Trimen as Director of Gardens, Hakgala turned over a new leaf. The Experimental Garden took a different layout, the aesthetic aspect of the Garden was developed and the establishment of a Botanic Gardens came into being. Useful and ornamental plants were introduced from all parts of the world and planted in the warm temperate and subtropical garden in the hills. Experimental work however did not cease. Mr. Nock took metereological observations and got on record the large number of rainy days. This also explained why so many plants at Hakgala perished. Wet weather, persistent cold, "high winds occasionally approaching hurricane force accompanied the heavy rains from mid-May to mid-September". The Climate then was evidently not quite suitable for Cinchona. So was the shallow

Ornamental Garden--Hakgala

Ceylon Pond and Bulb Garden—Hakgala

soil and sub soil which was cold and wet at the base of the steep rock. Hakgala however had done its part in the introduction of Cinchona. But Cinchona did not have a bright future in Ceylon because planters did not heed the warning given by Hakgala in the direction of cultivation of better varieties of Cinchona which were more difficult to cultivate. Easier varieties were cultivated and the bark from these did not realize high prices for long. Gradually the prices of Ceylon bark fell although the exports increased (from about 3 million in 1882 to over 15 million in 1886). But from this peak the exports too started dropping. In 1887 the Director's report commented " The history of this industry in Ceylon however unsatisfactory, has been most instructive, and has fully shown the truth of what was so strongly insisted upon from the first by those who looked ahead, that quality and not quantity, was the object to be aimed at by the grower. This more far seeking policy has been followed in other countries like Java ".

The eighteen eighties saw the rise and fall, in some cases, of three different industries that so materially affected the economy of the island. The coffee industry was falling fast and tea was taking tremendous strides ahead and filling in the gap between these two, was Cinchona which had its rise and fall in this one decade. Tea was progressing rapidly, the export in 1881 being about 300,000 lbs. while at the turn of the century, in 1900, 148 million pounds were being exported to countries like the U. K., U. S. A. and Russia. Tea estates were opened up at all elevations from sea-level to the highest available land in the wet district. Dr. Thwaites prophecy of 1870 came true, and in all this the Botanic Gardens of Ceylon, and Hakgala in particular played a vital role.

While helping the country in solving economic problems Hakgala carried on another role of making itself useful to the country. There were numerous plants that had to be experimented with. Amongst the drugs were Taraxacum, Rhubarb. Belladonna Hyoscyamus, Digitalis and Camomile (1882). Amongst the fibre there were the New-Zealand flax Phormium tenax (1890) Bohemaria tenanissima (1888), Villebrunia integrifolia. Amongst fodder plants there were lucerne or alfalfa (Medicago sativa 1892) Paspalum dilatatum, Bromus inermis, Panicum maximum, Trifolium Johnsonii, Teosinite.

Acacia decurrens (1899) and Rumex hymenosepalus (1875) produced tannic acid. The English laurel was established in 1901 while Holly planted in 1895 berried for the fist time in Ceylon in 1900. Amongst the fruits, a number of English fruit plants were tried out at Hakgala some of them thriving well, apples, pears plums, peaches, black berries, raspberries mulberries, figs, cherries, cherimoyer, loquat, mountain papaw and several others. Numerous vegetables were also introduced, amongst them was the Cho-Cho (Sechium edule), the tree tomato (Cyphomandra betacea) the South American parsnip (Arracacha esculenta), the Chinese or Japanese Artichoke (Stachys tuberifera), Shantung cabbage (Brassica chinensis) Ullucus tuberosus almost a substitute for potato, and potato itself of which numerous varieties were tried out in 1899 some of them proving highly successful.

A large number of trees were introduced suitable for the hill country which would find uses for timber, as wind belts and even as ornamental plants. With the tea industry, a search was made for suitable timber for tea boxes and there were many trees that answered to this purpose, some of them being Cryptomeria japonica, Cedrela toona and Pinus sinensis. Australian wattle acacias were tried out and the Silver wattle, Acacia dealbata was found to be an ideal fuel tree for the tea industry.

Amongst the plantations were collections of Eucalyptus, Conifers, Pines, Acacias and Camphor plantations which exists to this very day. Trials on these were carried out as far back as 1882 and their growth measured through the succeeding years. Over 50 species of Eucalyptus were planted out, amongst them were the Tasmanian Blue Gum, Eucalyptus globulus, and red gum Eucalyptus robusta. In the conifers were a number of genera and species that proved to be valuable as timber, for dyes, for tanning, for obtaining turpentine, for fuel and even for use as wind belts. Amongst these were Cupressus macrocarpa (the Monetary Cypress of California) planted in 1881, Cedrela toona (the Red Cedar of Queensland), Pinus longifolia (the Chir Pine of the Himalayas), Cryptomeria japonica (the Japanese Pencil Cedar, 1874), Cupressus knightiana (the knight's cypress), Cupressus torulosa (the towering Cypress of the Himalayas), Cupressus funebris (the weeping cypress of China), Cupressus

bermudiana (the Pencil Cedar of Bermuda), Cupressus sempervirens variety horizontalis (the spreading Cypress of Crete) and a host of other conifers, besides which there were trees like Syncarpia glomulifera (the turpentine tree of New South Wales, 1890) Grevillia robusta (the silky oak of Australia), Tristania conferta (the Queensland Red box). There was also a collection of Oak, planted in 1883 that produced acorns in 1892. Several other species were tried out in the succeeding years. A number of species of Acacias were put on trial and these thrived well. In this way a large number of trees were introduced.

In the years that followed the face of the Gardens changed and with the trend towards a Botanic Gardens, efforts were made towards the cultivation of specimen plants of genera growing in the temperate and subtropical world. Today such a collection is seen in the trees, shrubs and herbs scattered in the different parts of the Gardens such as the Fernery with its proud collection of ferns and its unmistakable and characteristic wooly tree ferns, Alsophila crinita, so much like palms at their full height of 30 to 40 feet ; the rock Gardens with their dwarf foliage and flowering plants rich in their colour and varied in their origin, but all assembled together to produce a profusion of colour; the Water Gardens with blue and yellow Nymphaeas, Aponogetons and other water plants; the Bulb Gardens with numerous species of lilies, gladioli and other bulbs, and the Arboretum with a collection of trees from Europe in the North, Australia in the South, from Japan in the far East and from distant California in the West. While all this forms a wealth of information to the Botanist, the layout in the Ornamental Section with its variety of annuals, the Rose Gardens with its numerous Hybrid tea, floribunda and climbing or rambler roses, the Herbaceous Borders with their blaze of colour and the spreading lawns of the Australian Blue Grass (Digitaria diidactyla) lend an enchanting view to the layman who visits the gardens for its aesthetic charm and beauty.

But the role that Hakgala has played in its historic past is still seen as one drives through the slopes of the hill country, extensively covered with tea and numerous foreign trees dotted on the hill sides, and these living monuments bear testimony to Hakgala's contribution towards the economic development of this Island.

SCIENTIFIC NOTES

Empoasca punjabensis Pruthi, a newly recorded pest of Teak in Ceylon

THE leafhopper, *Empoasca punjabensis* pruthi attacking Teak, *Teckona grandis*, in Ceylon was first recorded in February, 1961 at Melsiripura in the Kurunegala district.

The leafhoppers were found to cause severe damage to approximately 200,000 trees of Teak by producing a mal-formation of the leaves. The outbreak of this pest occurred shortly after a period of intermittant rains that followed a long spell of dry weather.

E. punjabensis was originally recorded in India as a pest of potato, tomato, cotton, carrot, bean and lucerne (pruthi, 1940). On Teak, the adults and nymphs infest the lower surfaces of the leaves between the primary veins. Their feeding activity results in leaf spotting and necrosis of leaf tissue in the inter-venial areas.

Leaves that have been subjected to attack at an early stage become navicular in shape as they mature. At this stage decaying of tissue commences at the margins and inter-venial regions of the leaves. (Fig. I & II).

Females oviposit on the leaf veins. Nymphal life varies from approximately 15 to 16 days at an average temperature of 23° C. The nymphs being non-migratory cause relatively more damage than the adults. *E. punjabensis* was effectively checked by dusting the teak plants with 3 per cent gamma BHC at the rate of 20 lbs. per acre.

REFERENCES

PRUTHI, H. S. (1940). Description of some new species of *Empoasca* Walsh (Eupterygidea, Jassoidea) from N. India. Ind. J. Ent. 2 (1) 1—10.

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Fig. II—The sequence of malformation of leaves seen in a single teak plant

Fig. I—Six stages in the abnormal development of teak leaves caused by *E. punjabensis*

METEOROLOGICAL REPORT

Summary for July to September 1961

THE active monsoon conditions which prevailed at the end of June continued for a few days in July giving fairly widespread rain and occasional gusts of strong wind along the southwestern coasts. These conditions began to ease off about the 6th and from the 8th to 17th the weather over the Island was fair except for a few isolated light showers. The monsoon was again active from the 19th to 21st, when gusts of wind reaching gale force at times were experienced in the southwestern coastal areas, with fairly heavy rain in the southwest quarter on the 20th and 21st. Normal monsoon conditions prevailed during the rest of the month, except on the 28th when there was again a temporary strengthening of the monsoon, resulting in several stations on the southwestern slopes of the hills receiving rainfalls over 5 inches. The greater monthly totals of rainfall occurred along the southwestern slopes of the central hills and were of the order of 20 inches. Southwestern coastal areas recorded totals between 5 and 10 inches. Outside the southwest quarter the totals were below 5 inches. About 25 stations, mostly in the north, received no rain at all. Rainfall was above normal in the southwestern lowlands and adjacent mid-country and in the northwestern, southern and eastern coastal areas and below normal elsewhere. About 15 daily falls over 5 inches were recorded, almost all on the 28th the highest was 7.42 inches at Nelluwa (Hiniduma) on this date.

Southwest monsoon was fairly active during August too, and monsoon rain was experienced almost daily in the southwestern parts, particularly in the hill country. In the low country the number of days on which rainfall occurred exceeded the average by 8 to 10 days. Active conditions were well in evidence on the 1st and 6th and again from the 9th to 15th, when occasional rainsqualls and gale force winds were experienced in the southwestern low country. Gales on the 12th morning were particularly severe and caused much damage to house and property, uprooting trees in plantations lifting roofs off buildings at several places in the coastal belt between Colombo and Matara. Isolated thunder activity was evident outside the southwest quarter on a few occasions during the first half of the month, while they were fairly widely experienced during the last few days. Rainfall was heaviest on the southwest slopes of the central hills and was of the order of 30 to 40 inches. In southwestern coastal areas the rainfall was generally of the order of 10 inches. Outside the southwest quarter the monthly aggregates were below 5 inches practically everywhere. About forty-five stations, mostly in the north, received no rain at all. Rainfall was above normal in the southwest and below normal elsewhere. There were no daily falls over 5 inches.

Active southwest monsoon weather continued during September too, particularly in the southwestern coastal areas and the adjacent low country. In these regions cloudy skies prevailed throughout the month with rain almost every day. On some days between the 10th and 25th, the rains were fairly heavy and accompanied by squally weather, on account of the presence of low pressure areas over the North Bay of Bengal. Evening thunderstorms were experienced on several days of the month over the central and eastern parts of the island. Rainfall was heaviest in the southwestern low country and in the neighbourhood of Deraniyagala where the monthly totals were of the order of 25 inches. Among the central hills the rainfall generally ranged from 2 to 10 inches. Outside the southwest quarter, except in parts of the Eastern Province and Uva, the monthly totals were below 5 inches. A few stations, mostly in the Mannar and Jaffna Districts, received no rain at all. Rainfall was well above normal in the southwestern low and mid-country and a little above normal in the Badulla area and in the southern half of the eastern province. It was below normal elsewhere. There were eight daily falls over 5 inches, 5.44 inches at Ragama on the 26th being the highest.

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27th November, 1961.

Meteorological Report

Station	JULY, 1961										
	Temperature				Humidity		Amount of Cloud	Rainfall			
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min.)		Amount	Offset	Rain Days	Offset
	°		°		%	%		Inches	Inches		
Anuradhapura	89·2	—1·7	74·6	—1·2	70	90	6·9	0·82	—0·50	7	+ 4
Badulla ..	86·7	+0·5	64·6	+0·3	63	91	6·2	1·66	—0·51	9	+ 2
Batticaloa ..	90·3	—1·6	74·9	0	68	84	5·6	1·99	+0·95	5	+ 1
Colombo ..	85·3	+0·6	75·3	—1·6	82	91	6·8	8·84	+3·35	15	— 1
Diyatalawa ..	77·1	—0·8	61·0	—1·5	66	80	6·6	1·07	—0·89	8	+ 1
Galle ..	83·4	+0·7	77·0	+0·4	78	84	5·6	8·11	+1·77	19	0
Hambantota ..	83·6	—3·7	75·9	—0·4	82	88	5·6	4·34	+2·33	12	+ 4
Jaffna ..	85·1	—1·0	79·7	—0·1	81	87	6·6	0·22	—0·33	2	+ 1
Kandy ..	82·1	+1·0	68·4	—1·4	66	85	6·9	5·81	—0·08	15	— 2
Kankesanturai	89·0	—0·9	79·6	+0·5	72	85	6·6	0·70	+0·16	1	0
Kurunegala ..	86·8	+0·5	74·7	—0·5	73	88	7·4	3·59	—0·29	10	— 5
M'Illuppallama	88·4	—1·2	74·4	—0·5	66	84	6·6	1·18	—0·25	6	+ 3
Mannar ..	87·2	—0·1	79·6	+0·5	79	87	7·0	0·82	+0·47	2	+ 1
Nuwara Eliya	66·1	+0·8	54·6	—0·3	79	85	6·6	6·06	—4·96	16	— 8
Puttalam ..	86·2	0	77·5	—0·7	70	78	6·9	2·47	+1·48	14	+ 11
Ratmalana ..	85·7	+1·0	75·8	—0·5	74	86	6·9	7·26	+1·80	16	—
Ratnapura ..	88·4	+1·8	72·5	—1·9	66	83	6·5	15·43	+2·66	18	— 6
Talawakele ..	—	—	—	—	—	—	—	—	—	—	—
Trincomalee ..	92·8	+0·4	78·0	—0	61	78	6·6	4·31	+2·58	5	+ 2
Mullaitivu ..	94·3	—	77·2	—	60	82	6·4	2·03	+0·53	6	—
Katunayake ..	85·6	—	75·4	—	78	91	6·6	4·02	—	12	—
Vavuniya ..	91·7	—	75·4	—	61	86	6·6	1·13	+0·05	5	—

AUGUST, 1961

Station	Temperature				Humidity		Amount of Cloud	Rainfall			
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min. Temps.)		Amount	Offset	Rain Days	Offset
	°		°		%	%		Inches	Inches		
Anuradhapura	92·0	+0·6	76·0	+0·5	62	86	6·5	0·22	—1·40	5	+ 1
Badulla ..	86·8	+0·8	65·9	+1·4	63	92	6·6	2·55	—0·65	13	+ 4
Batticaloa ..	90·8	+0·4	77·2	+0·7	68	82	6·0	1·72	—0·23	9	+ 3
Colombo ..	85·2	+0·3	76·6	—0·4	81	86	7·0	9·56	+5·53	24	+10
Diyatalawa ..	77·2	—0·7	63·4	+1·7	65	91	6·6	0·77	—2·35	14	+ 5
Galle ..	82·5	—0·1	75·9	—0·8	80	84	6·4	11·47	+5·33	29	+10
Hambantota ..	83·5	—3·4	75·7	—0·4	83	88	6·7	4·47	+3·03	20	+12
Jaffna ..	85·7	—0·3	80·3	+1·0	82	87	5·9	0	—1·11	—	— 3
Kandy ..	81·4	—0·8	70·1	+0·4	72	85	7·0	5·98	+1·24	24	+10
Kankesanturai	90·5	+0·5	80·0	+1·0	71	85	5·9	0·01	—1·25	1	— 2
Kurunegala ..	86·4	—0·4	75·5	+0·6	75	88	7·3	3·78	+0·16	18	+ 4
M'Illuppallama	91·2	+0·4	75·8	+0·6	60	82	6·8	0·26	—1·35	11	+ 8
Mannar ..	87·6	+0·2	79·6	+0·6	81	89	6·6	0·05	—0·61	1	— 1
Nuwara Eliya	64·3	—1·8	56·2	+1·8	88	91	7·5	8·44	+0·93	27	+ 5
Puttalam ..	87·1	+0·5	78·6	+0·7	68	76	6·8	1·36	+0·71	5	+ 2
Ratmalana ..	85·6	+0·4	76·9	—0·4	75	84	6·9	11·69	+8·21	24	—
Ratnapura ..	86·7	—0·1	73·8	—0·4	71	84	6·9	20·36	+8·97	28	+ 5
Talawakele ..	—	—	—	—	—	—	—	—	—	—	—
Trincomalee ..	93·8	+1·7	78·5	+1·2	63	80	6·2	2·30	—1·31	3	— 4
Mullaitivu ..	95·1	—	77·0	—	60	86	5·6	2·63	+0·68	8	—
Katunayake ..	86·0	—	76·7	—	79	86	6·8	4·44	—	16	—
Vavuniya ..	93·4	—	76·0	—	57	84	6·5	0	—2·37	—	—

SEPTEMBER, 1961

Station	Temperature				Humidity		Amount of Cloud	Rainfall			
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min. Temps.)		Amount	Offset	Rain Days	Offset
	°		°		%	%		Inches	Inches		
Anuradhapura	92·7	+0·9	74·6	—0·4	60	88	6·1	0·79	—2·97	8	+ 1
Badulla ..	84·8	—0·9	65·3	+1·0	70	92	6·0	3·80	—0·69	14	+ 4
Batticaloa ..	88·4	—1·3	75·5	—0·7	73	88	5·6	3·39	+1·00	7	+ 1
Colombo ..	85·3	—0·1	74·2	—2·3	83	90	7·0	16·79	+9·95	26	+ 9
Diyatalawa ..	75·5	—2·3	61·8	+0·9	74	84	6·0	4·42	+0·01	15	+ 4
Galle ..	82·9	+0·1	74·8	—1·9	80	86	6·2	14·86	+6·05	26	+ 8
Hambantota ..	84·1	—2·4	75·6	—0·5	80	86	6·5	11·37	+8·61	16	+ 7
Jaffna ..	85·9	—0·3	79·7	+0·4	81	85	5·4	0·31	—2·22	2	— 2
Kandy ..	82·6	+0·4	67·6	+0·1	69	87	6·6	4·12	—1·86	16	+ 2
Kankesanturai	90·2	+0·4	79·2	+0·1	70	85	5·0	1·31	—1 66	3	— 1
Kurunegla ..	86·8	—0·9	73·8	—0·5	75	90	7·8	7·83	+2·28	15	+ 1
M'Illuppallama	91·5	+0·3	74·4	—0·3	58	81	6·2	0·87	—2·18	5	0
Mannar ..	88·3	+0·6	79·9	+1·0	78	85	6·0	0	—1·24	0	— 3
Nuwara Eliya	66·5	—0·3	54·2	+0·9	83	91	6·8	4·80	—3·44	20	0
Puttalam ..	88·2	+1·2	77·4	—0·4	65	78	6·2	2·28	+0·70	13	+ 7
Ratmalana ..	85·6	—0·1	74·6	—1·8	76	88	7·0	14·83	+7·99	26	—
Ratnapura ..	87·3	+0·1	72·2	—1·3	71	85	6·7	18·57	+4·05	26	+ 5
Talawakele ..	—	—	—	—	—	—	—	—	—	—	—
Trincomalee ..	92·2	+0·1	76·5	—0·6	67	84	6·0	2·61	—0·82	10	+ 2
Mullaitivu ..	93·6	—	75·6	—	62	86	4·8	2·38	—0·31	6	—
Katunayake ..	85·6	—	74·1	—	80	93	6·4	17·88	—	24	—
Vavuniya ..	93·9	—	74·8	—	57	86	6·0	0·28	—3·45	6	—